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DEPARTMENT OF THE INTERIOR
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May 14, 1987

Ed's signature Due 6/1

Forwarded for review 6/4/87. R.F.F

To: Interested Parties

Attached is a draft report on the findings of a fish tumor survey conducted by this office on brown bullheads from Presque Isle Bay in 1985. Although we are still waiting to receive the results of analysis of bile collected during the survey, a high rate of requests for the results of the histopathology work has prompted us to make this preliminary report available now.

You have been included on our list of report recipients because you represent an agency with statutory responsibilities related to water quality, and/or because you have telephoned our office requesting the information. If you have any comments or questions concerning the report, please submit them to us within 30 days.

Sincerely,

Charles J. Kulp
Field Supervisor

Copies sent to:

Erie County Department of Health - Wellington
PA DER - Hasse, Ulanoski
PA Fish Commission - Kenyon, Hesser, Arway
U.S. FWS - Hickey, Julin
Mercyhurst College - Kubiak, Campbell, Lutton, Paydock
International Joint Commission - Edwards
Erie County Environmental Coalition - Lintelman
WSEE TV, Erie, PA - Tarbell
Office of Congressman Tom Ridge

Jim Wiancko

DRAFT

STATE COLLEGE FIELD OFFICE
ENVIRONMENTAL CONAMINANTS REPORT NO. 87-8

PRELIMINARY REPORT

RESULTS OF 1985 SURVEY OF TUMORS IN BROWN BULLHEADS FROM PRESQUE ISLE BAY, LAKE ERIE, ERIE, PENNSYLVANIA

Department of the Interior
U.S. Fish and Wildlife Service
State College, Pennsylvania

May 1987

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Environmental Contaminants Report No. 87-8

PRELIMINARY REPORT

Results of 1985 Survey of Tumors in Brown Bullheads from Presque Isle Bay, Lake Erie, Erie, Pennsylvania

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Project Leader: Charles J. Kulp

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Erie County Department of Health	- Robert Wellington
Pennsylvania Department of Environmental Resources	- Ray Hasse
Mercyhurst College	- Richard Kubiak - Mike Campbell - Lewis Lutton - Eymard Paydock
New York State Department of Health (Roswell Park Memorial Institute)	- Jack Black - Lex Maccubbin
U.S. Fish and Wildlife Service	- John Hickey - Arnold Julin

We also extend our appreciation to many concerned citizens of Erie, for their patience in waiting for the results of this survey, which were delayed by situations beyond the control of this office.

INTRODUCTION

The U.S. Fish and Wildlife Service (Service) has been concerned with environmental contaminants since the late 1940's when researchers began investigating the impacts of synthetic organic pesticides, such as DDT, on fish and wildlife resources. Publication of Rachel Carson's Silent Spring focused nationwide attention on the biological and ecological effects of massive use of persistent chemical compounds.

Over the past several years, the Service has been working to improve its field operation capabilities to address and enhance the quality of fish and wildlife resources impacted by environmental contaminants. Service field offices nationwide have established "Environmental Contaminants" programs with responsibility for identifying contaminant threats to fish and wildlife and recommending actions to eliminate those threats. The results of the Service's monitoring, field assessment and research initiatives are indicating that a broad spectrum of contaminants are affecting fish and wildlife throughout the United States. Aberrations such as backbone deformation, liver tumors, alteration of enzyme activity and function, and reduced nesting success, are being detected with increasing regularity in research and field studies of natural populations.

The general public in the United States has become increasingly well-educated about chemical contaminant issues and private citizens frequently alert the Service to pollution problems. Such was the case in 1984, when the Service's State College, Pennsylvania Field Office (SCFO) began receiving periodic reports from citizens in the vicinity of Erie, Pennsylvania that brown bullheads (Ictalurus nebulosus) caught by fishermen in Presque Isle Bay area exhibited skin and lip "tumors." In response to these reports, SCFO staff collected brown bullheads from the Presque Isle Bay area in the summer of 1984. The collection effort was designed as a preliminary survey to verify the persistent rumors and determine whether a more elaborate study of the problem was warranted. Less than 50 brown bullheads were examined, but many of these exhibited a wide array of external lesions. Skin and internal organ tissue samples were collected for pathological examination, and whole fish samples were saved for chemical analysis. The results verified the presence of benign skin tumors in a few of the sampled brown bullheads. Chemical analysis of the whole fish revealed the presence of a variety of organochlorine pesticides and an unexpectedly high level of PCB's.

While a number of researchers have discovered higher fish tumor rates in industrialized areas than in relatively unpolluted waters, fish skin tumors cannot be considered absolute proof that chemical carcinogens are present. Fish liver tumors (not observed in the fish we collected) would more strongly indicate the presence of a carcinogenic agent.

The histopathology results of the 1984 work had not been received by the beginning of the 1985 spring/summer field season. Because the gross abnormalities we observed on the fish the previous year indicated that a fish health problem existed in Presque Isle Bay, we decided that a more detailed survey of this problem was warranted. Concerned that in waiting for the 1984 results we could lose the entire 1985 field season, we proceeded with the detailed survey in May 1985.

The following report describes our methods and results of the 1985 survey.

METHODS

Brown bullheads were collected from several locations in Presque Isle Bay by staff from the U.S. Fish and Wildlife Service (Dave Putnam and Cindy Rice), Erie County Department of Health (Bob Wellington) and Pennsylvania Department of Environmental Resources (Ray Hasse). Fish were collected by electroshocking the "Lagoons" area (Big Pond and Long Pond) on May 6; these fish were kept alive in cages overnight at the Cherry Street marina. A few additional brown bullheads were obtained on May 7 from trap nets set near Mill Creek and at the mouth of Cascade Creek. Figure 1 shows the collection locations. The Lagoons area appears to be a spawning ground for brown bullheads as well as other species, and the area is a noted "hot spot" for spring bullhead fishing. Biologists familiar with brown bullhead habits have informed us that these fish probably travel throughout Presque Isle Bay; therefore, it would not be valid to attempt to interpret any differences between fish collected from different locations within the Bay.

The fish were taken from the boat or removed from the wire cages, immediately placed on ice, and transported to a biology laboratory at Mercyhurst College. There, Service biologists Putnam, Rice and John Hickey (Cortland, New York Field Office); ECDH biologist Wellington; PADER biologist Hasse; and Roswell Park Memorial Institute pathologist Lex Maccubbin were assisted by Mercyhurst Staff and an unending stream of enthusiastic student volunteers in the collection of fish tissues.

Each brown bullhead was first euthanized by severing the spinal cord, then subjected to a rigorous examination for any gross external abnormalities. A description (including shape, size, color, and type) and the location of any lesions were recorded on data sheets. In most cases, any oral or skin papillomas or other turmor-like lesions were collected.

Next, the internal organs were examined, and any abnormalities recorded. The appearance of the liver was carefully noted. Samples of liver tissues were taken from each brown bullhead whether the liver looked normal or not. In addition, bile was collected and immediately frozen for future analysis.

All tissues collected for histopathology were preserved in 10 percent buffered formalin. The samples were kept separate for each fish, and labeled with the data sheet identification number. The samples were transported by Lex Maccubbin to the Roswell Park Memorial Institute (New York State Department of Health) in Buffalo, New York. The tissues were processed and diagnosed by Drs. Maccubbin and John J. Black, operating under the terms of a cooperative agreement with the Service.

In addition to the histopathology samples, we also saved fish for chemical analysis. Two composite samples consisting of five whole brown bullheads each (sample numbers R5-85-SCFO-3-1 and R5-85-SCFO-3-2) were collected from the "Lagoons" area. In addition, a fillet sample composited from three brown bullheads collected off the mouth of Cascade Creek (R5-85-SCFO-3-3b) and a fillet from a single muskellunge (R5-85-SCFO-3-4), also caught off Cascade Creek, were split with ECDH.

Samples 3-1 and 3-2 (the whole brown bullhead composites) were analyzed for metals, organochlorines, PCBs, and polycyclic aromatic hydrocarbons. Samples 3-3b and 3-4 (the bullhead and muskellunge fillets) were analyzed only for organochlorines and PCBs. The chemical analyses were conducted by the Mississippi State Chemical Laboratory, Mississippi State University (organics), and the Environmental Trace Substances Research Center, Columbia, Missouri (metals). Both laboratories perform work for the Service under contracts administered by the Service's Patuxent Analytical Control Facility in Laurel, Maryland.

RESULTS

Chemical Analysis

Tables 1, 2 and 3 show the results of the chemical analysis of fish collected from Presque Isle Bay during this survey.

Histopathology

Tissue samples from a total of 93 fish were sent to Roswell Park for histopathology work. Oral or skin abnormalities had been noted on 37 of these fish during the gross external examinations. The Roswell Park diagnoses for these 37 are as follows:

Oral neoplasms	9
Skin neoplasms	2
Epidermal hyperplasia	9
Non-neoplastic	2
Normal	1
Missing slides, bad sections, or no diagnosis	12
No tissue sample collected	2

If the 12 samples for which slides were inadequate or no diagnosis was given are discounted, 81 fish were diagnosed (93 - 12 = 81). Of these, nine cases of oral neoplasms were documented, for an incidence of 11% (9/81). Two cases of skin neoplasms were recorded, for an incidence of 2.5%. The incidence of epidermal hyperplasis (a non-neoplastic thickening of the skin) was also 11%. Interestingly, only 30% of the gross observations (11/37) were actually verified as neoplasms; this rate may have been higher had the 12 additional samples been diagnosed.

No liver neoplasms were diagnosed in any of the 93 samples.

Bile Samples

The results of analysis of bile samples collected from the brown bullheads have not yet been received from Roswell Park.

Table 1. Results of metals analysis of fish collected in Presque Isle Bay in May 1985, compared with the National Contaminant Biomonitoring Program "85th percentile" (see text for explanation). All results in ppm wet weight.

	Sample No. (R5-85-SCFO-), Species, and Type		
	3-1 Brown Bullhead (whole)	3-2 Brown Bullhead (whole)	NCBP 85th Percentile*
Percent Lipid	4.7	4.3	
Percent Moisture	74.8	77.0	
Aluminum	3.4	11.0	
Arsenic	0.06	0.05	0.22
Beryllium	<0.005	<0.005	
Cadmium	<0.05	<0.05	0.06
Chromium	0.1	0.1	
Cobalt	<0.05	30.8	
Copper	0.72	1.0	0.90
Iron	63.3	64.7	
Lead	0.3	<0.2	0.25
Mercury	0.02	0.03	0.18
Manganese	3.13	3.60	
Nickel	0.61	0.71	
Selenium	0.27	0.30	0.71
Thallium	<1.	<1.	
Zinc	13.7	12.5	40.09

*Source: Lowe, T.P. et al. 1985

Table 2. Results of organochlorine and PCB analysis of fish collected from Presque Isle Bay in May 1985, compared with the National Contaminant Biomonitoring Program geometric means and maxima (see text for explanation). All results in ppm wet weight.

	Sample No. (R5-85-SCFO-), Species and Type				NCBP (whole) *	
	3-1 Br. Bullhead Whole	3-2 Br. Bullhead Whole	3-3b Br. Bullhead Fillet	3-4 Muskellunge Fillet	Geometric Mean	Max.
Percent Lipid	4.7	4.3	2.4	2.6		
t-Nonachlor	0.03	0.04	0.01	0.03	0.04	0.77
Dieldrin	0.01	0.01	0.01	0.01	0.04	0.72
p,p'-DDE	0.08	0.08	0.03	0.05	0.20	2.57
p,p'-DDD	0.04	0.03	0.02	0.03	0.07	3.43
PCBs	0.80	0.38	0.15	0.72	0.53	11.30

The following compounds were not detected in any of the Presque Isle Bay fish samples: HCB; total BHC; oxychlordane; heptachlor epoxide; gamma chlordane; toxaphene; o,p'-DDE; alpha chlordane; o,p'-DDD; endrin; cis-nonachlor; o,p'-DDT; p,p'-DDT, and mirex. Lower level of detection for organochlorines is 0.01 ppm; for PCBs and toxaphene, 0.05 ppm.

*Source: Schmitt, C. J. et al, 1985.

Table 3. Results of polycyclic aromatic hydrocarbon analysis of whole brown bullheads collected from Presque Isle Bay in May 1985, compared to PAH concentrations in composite brown bullhead samples from the Black River, Ohio. All results in ppm wet weight.

	Presuqe Isle Bay Brown Bullheads Sample No. (R5-85-SCFO-)		Black River Brown Bullheads (Mean concentration of five determinations)
	3-1	3-2	
Phenanthrene	0.080	0.030	1.219
Fluoranthrene	0.010	ND	0.775
Pyrene	0.010	ND	0.423
Chrysene	0.010	ND	0.047

The following additional compounds were not detected in the Presque Isle Bay samples: 1,2-benzanthracene; benzo(b)fluoranthrene; benzo(k)fluoranthrene; benzo(e)pyrene; benzo(a)pyrene; 1,2,5,6-dibenzanthracene; and benzo(g,h,i)perylene; naphthalene; fluorene and anthracene. Of these compounds, naphthalene, fluorene and anthracene were present in Black River fish.

ND = none detected.

DISCUSSION

Chemical Analysis

Table 1 shows the results of metals analysis for two composite brown bullhead samples collected from the bay, compared to the 85th percentile value for levels of seven metals inlcuded in the Service's National Biomonitoring Program (NCBP) in 1980-1981. The NCBP analyzes fish for heavy metals, organochlorines and PCBs at over 100 stations nationwide. Following analysis of the data, the 85th percentile is calculated for station mean concentrations. The 85th percentile was selected as "an arbitrary point distinguishing NCBP stations with 'high' concentrations of elements. It has no meaning with respect to either potential hazards to fishery resources or regulatory statutes" (Lowe et al. 1985; p. 366). However, it is considered a useful figure to represent a level considered to be "above background" (McKinney 1981). Of the seven metals, copper and lead were slightly higher than the 85th percentile value in the Presque Isle Bay fish; arsenic, cadmium, mercury, selenium, and zinc values were well below this value.

Table 2 shows the results of analysis of four Presque Isle Bay fish samples for organochlorines and PCBs, compared to the 1980-1981 geometric mean and maxima values. All of the organochlorines detected in our samples were at or below the geometric mean concentrations. PCBs in two of the samples (3-1, whole brown bullhead composite; and 3-4, single muskellunge fillet) exceeded the NCBP geometric mean but were far below the maximum value.

The levels of polycyclic aromatic hydrocarbons (PAHs) detected in samples 3-1 and 3-2 are shown in Table 3, along with values for the same compounds in fish from the Black River in Ohio, where high tumor rates in brown bullheads have been documented. PAH contamination in the Black River is considered to be high. The levels of PAHs in the Presque Isle Bay fish are below the Black River values. However, the laboratory analysis does not include the metabolites of the PAH compounds, believed to be the actual inducers of PAH-related fish tumors. Some fish tumor researchers theorize that PAH levels in fish tissues may undergo seasonal changes, perhaps being high in the spring following the winter period of low metabolic activity, and low in late summer. During periods of low PAH tissue levels, PAH metabolites might be present in higher concentrations. Unfortunately, this is just a theory and laboratory techniques for analyzing PAH metabolites are not fully developed at this time (pers. comm., Zajicek 11/25/85).

There were no obvious differences between the fish analysis conducted in 1984 versus 1985. Organochlorine levels were generally lower in the 1985 samples, but this may be due to a lower lipid content in these fish compared to the 1984 samples.

Histopathology

Although the 11% incidence of oral and skin neoplasms observed in the Presque Isle Bay brown bullheads in the 1985 survey would appear to be a cause for concern, it is not possible at this time to conclusively pinpoint a cause. Viruses have been found to cause tumors in some species of fish, but electron microscopy has failed to detect any viral agent associated with bullhead tumors (Harshbarger, pers. comm., 11/22/85).

There is increasing interest among researchers in the possibility that tumors in fish populations could offer an early-warning signal of environmental contamination. Such was the case in the early 1960's, when an international epidemic of liver cancer in hatchery-reared trout led to the discovery that a mold growing on peanuts used in trout food produced aflatoxins (Morell 1984). Aflatoxins have been identified as one of the most potent carcinogens known and are now regulated by the FDA.

Sonstegard (1977) necropsied over 50,000 fish from the Great Lakes and found epizootics (epidemic incidence) of tumors in carp (Cyprinus carpio), goldfish (Carassius auratus), carp x goldfish hybrids (Cyprinus carpio x Carassius auratus) and white suckers (Catostomus commersoni). In many cases, the high tumor incidences were clustered around polluted areas. Brown et al. (1973) compared fish from the polluted Fox River in Illinois to unpolluted Canadian waters (Lake of the Woods, Ontario) and found a much higher tumor incidence in Fox River fish versus fish from the same species at Lake of the Woods. Black (1983) has established a direct cause-effect link between contaminated sediments and skin tumors in brown bullheads; he painted a laboratory population of brown bullheads with an extract of PAH-laden sediments, and observed the development of epidermal hyperplasia and neoplasms within 12 months. Black used the same technique on mice and skin cancer developed almost immediately (Morell 1984).

Thus, while the presence of oral and skin neoplasms would seem to indicate the presence of chemical carcinogens in Presque Isle Bay, both Drs. Baumann and Harshbarger (pers. comm., 11/22/85) have advised us that skin tumors alone are not absolute proof of carcinogens. Much stronger indication of a carcinogen would be the presence of liver tumors, but none were observed in either the 48 bullheads we collected in 1984, or over 90 bullheads examined in 1985. Black (1983) has pointed out that the liver is the major organ for metablizing toxic chemicals into forms that can be eliminated from an organism. Thus, it is logical that liver tumors would occur more frequently in contaminant-stressed populations.

The Erie County Department of Health has sampled sediments in Presque Isle Bay and had the samples analyzed for PAHs. The ECDH has identified a number of "hot spot" areas of relatively high PAH contamination in the sediments -- levels comparable to other areas of the country where fish tumors have also been documented. The state-of-the art in fish tumor research has not yet reached the stage where this contamination can be unequivocably cited as the cause of the fish tumors. However, fish skin tumor rates have been shown to be higher in industrialized areas compared to relatively clean areas. Even if these tumors were virally induced, it would seem that the polluted nature of the fishes' habitat somehow makes them more susceptible to the viral agents, possibly through increased stress (Baumann, pers. comm., 11/22/85).

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